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(54) **Liquid crystal cell**

(57) The clearance between the carrier plates 2, 7 of a liquid crystal display cell is maintained by means of fibers 8 randomly distributed in an adhesive 9. The fibres have a diameter of 2 to 15 μm and a maximum length of 200 μm. The adhesive forms both a border 10 and a regular grid of fixing points in the display area.

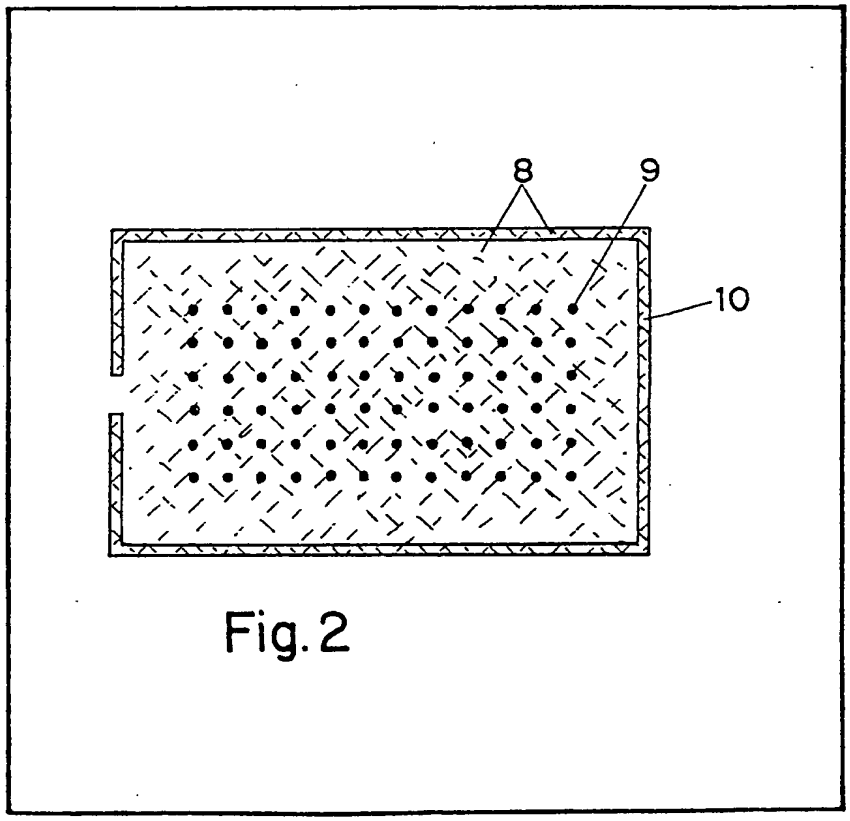

Fig. 2

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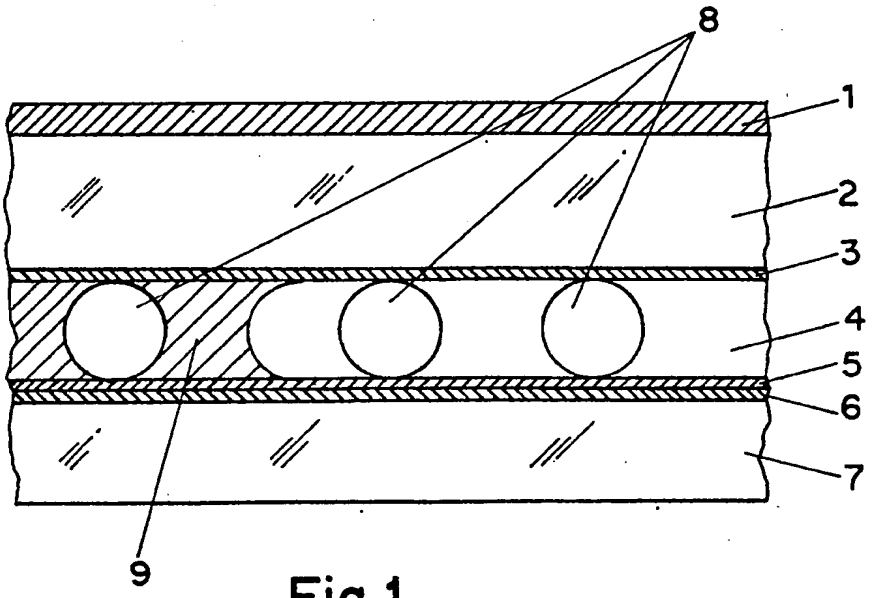

Fig.1

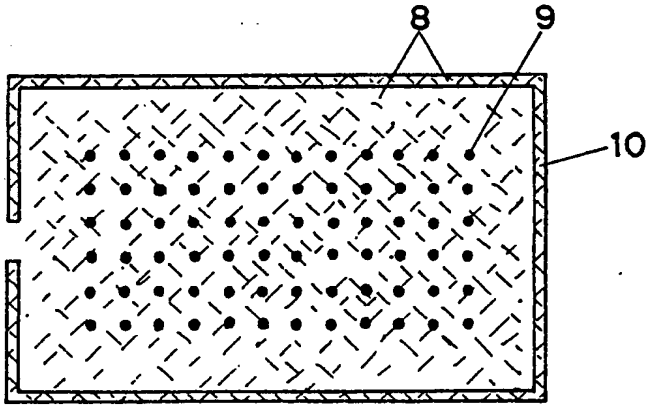

Fig.2

SPECIFICATION

Display device with liquid crystal and process for its manufacture

This invention relates to a display device of a type processing two mutually parallel carrier plates which, with a border, which is made of fiber-type material and defines the clearance between the carrier plates, form a cell, into which a liquid crystal layer is introduced, processing a front electrode and a rear electrode, possessing additional fibers, as spacers, in the region of the liquid crystal layer, and with a cured adhesive.

The invention also includes a process for the manufacture of a display device of the type mentioned above.

A process for the manufacture of a device of this type is known from German Offenlegungsschrift 2,635,942. As spacers, glass fibers are sheathed in an adhesive, which is then cured. The sheathed glass fiber forms a flexible wire, which has an external diameter of between 50 μm and 200 μm, and is located in the border on the substrate, the latter having first been sufficiently warmed. The two plates are pressed together so firmly that the adhesive escapes laterally, between the plates and the fiber, the latter coming into direct contact with the former. The glass fibers can also be arranged, as spacers, between the carrier plates, in the display region, in the same manner as in the border. The carrier plates and glass fibers are composed of an inexpensive soft glass.

The manufacture of the abovementioned display device, requiring many different production steps, is labor-intensive. The glass fibers, with the sheathing adhesive, are easily visible in the display region. It is impossible to produce very accurate and small clearances between the carrier plates, especially if the areas are large. It is impossible, for example to produce clearances of approximately 10 μm.

A cell for liquid crystal displays is known, from German Offenlegungsschrift 2,435,422, which possesses a very accurate clearance (3 ± 0.3 μm) between the carrier plates, which are made of glass, due to the presence of spacing cams which are etched-out in one carrier plate. The carrier plates are curved, in opposite directions, so that internal stresses are generated, these stresses holding the opposing surfaces, in the region of mutual contact, so that they are pressed against each other, via the spacing cams. The spacing cams have a diameter of 0.1 mm, and are located on the corner-points of a 5x5 mm network arrangement. The cell is bonded on the border, under pressure. The plates which are used exhibit a very accurate degree of flatness. They are subjected to a heat treatment, so that a virtually uniform curvature is produced, this curvature being far in excess of the curvatures which resulted from the waviness effects which were initially present.

The above cell has the disadvantage that its bonded edge must be rather wide, in order to prevent the cell from breaking open. Greater thicknesses must be chosen for the carrier plates, which are made of glass, as the area increases. The manufacturing process requires many different operations.

Accordingly, the present invention sets out to achieve the object of manufacturing a display device, which exhibits a very high accuracy with regard to the clearance between the carrier plates, while employing carrier plates of any desired area, and of any desired thickness. The intention is that the process for manufacturing a device of this type should comprise a small number of simple manufacturing steps.

The present invention provides a display device with liquid crystal, this being a device of the type first mentioned herein, wherein the border is composed of adhesive with a plurality of fibers, wherein the adhesive forms a regular grid, composed of adhesive fixing points, on the carrier plates, wherein the fibers have a diameter of 2 to 15 μm, and a maximum length of 200 μm, and wherein the fibers are randomly distributed over one of the carrier plates.

The invention also includes a process for manufacturing a display device as specified in the last preceding paragraph, wherein the adhesive is printed on by screen-printing, wherein the fibers are uniformly distributed over the carrier plate, and wherein the adhesive cures under a contact pressure which is constant both with respect to time and over the surface area.

Even when the display has a large surface area, the display device, according to the invention, exhibits a very accurate clearance, because the fibers, due to their small diameter tolerances, and the adhesive fixing points, as a result of their regular and fine grid, define the clearance between the carrier plates. The unit defining the grid is, with particular advantage, square or retangular, and has a point-separation of 1 to 10 mm. The adhesive fixing points also prevent any random migration of the fibers in the display device, thus ensuring that the device operates perfectly, even in the comparatively long term. The viewing area of the display is not disturbed by the fibers, since they are randomly distributed over the carrier plates, and possess the dimensions according to the invention. The fibers are composed of glass or plastic, since these materials have a high compressive strength and are very effective electrical insulators. The plastic fibers can best be manufactured from Kevlar, since this material can be processed very easily.

The invention can be used particularly advantageously in the case of a display device with an internal reflector, a circular polarizer, and homeotropic orientation of the anisotropic liquid crystal layer in the field-free state, this layer being dielectrically negative. A very accurate clearance between the carrier plates is important in a display device of this type.

Since, in display devices of this type, there must, on the one hand, be no optical phase change on reflection, while on the other hand,

undesired reflections must be prevented, the reflector is composed of aluminum flakes in a special layer.

The display device is manufactured, according to the invention, by the screen-printing technique. This technique also allows the adhesive and the fibers to be applied to the carrier plates at the same time. In order to maintain a very accurate degree of flatness over the carrier plates, and to maintain the clearance between them very accurately, the curing of the adhesive is carried out, in a grid of adhesive fixing points, according to the invention, under a contact pressure which is constant both with respect to time and over the surface area. The adhesive is preferably composed of an epoxy resin-based hot-melt bonding agent, because this adhesive produces a very good bond between the carrier plates.

By using a matrix arrangement of the electrodes, which are configured as lines of print, it is possible, for example, to manufacture television displays and graphics displays in a simple and inexpensive manner. Since plastic sheets can be manufactured with adequate flexibility, and with very flat surfaces, it is even possible to produce large-area display devices which are curved.

In the text which follows, the invention is explained in more detail, by reference to an example which is represented in Figures, in which:

Figure 1 shows a transverse section through a display device according to the invention, and

Figure 2 shows a plan view of a display device, with the grid of adhesive fixing points on a carrier plate.

Figure 1 shows a display device, with a circular polarizer 1, a front carrier plate 2, a front electrode 3, a liquid crystal layer 4, a reflector 5, a rear electrode 6, a rear carrier plate 7, glass fibers 8 and adhesive fixing points 9.

Although the front electrode 3 is drawn in one piece, it can also comprise a plurality of elements, in the form of digits. The front electrode 3 and the rear electrode 6 can also be configured as line-electrodes or column-electrodes of a matrix arrangement. The clearance between the carrier plates 2 and 7 is defined, according to the invention, by the glass fibers 8, which possess a diameter of 5 ± 0.2 μm and a length of approximately 50 μm, and by the adhesive fixing points 9. The thickness tolerance of the glass fibers 8 is very small. The liquid crystal layer 4 is composed of a nematic liquid crystal, with negative dielectric anisotropy, and is homeotropically orientated in the initial state. In the case of carrier plates which are less than 3 mm thick, the degree of flatness of the cell is determined virtually only the thickness tolerance of the internal reflector 5, by the spacers 8, and by the distribution of the spacers and of the adhesive fixing points. The internal reflector 5 is known, for example from German Offenlegungsschrift 2,629,765, and is composed of aluminum flakes, in a layer of CeO, MgO, SiO_2, TiO, TiO_2, ZrO_2, Al_2O_3, or Gd_2O_3. This layer is preferably composed of Gd_2O_3.

Figure 2 shows one of the carrier plates of the display device, with a border 10, and with a grid of adhesive fixing points 9. Glass fibers 8 are likewise present in the border 10. The electrode and the internal reflector are not drawn in this Figure. The adhesive fixing points 9 and the border 10 are applied to the carrier plate by screen-printing, and the glass fibers 8 are then randomly distributed over the plate. Alternatively, the glass fibers 8 are applied to the plate, together with the adhesive, by screen-printing. The adjusted cell is cured under a contact pressure which is constant both with respect to time and over the surface area. A thin cell-interspace is accordingly formed, its carrier plates being plane-parallel to an extreme degree. In the case of a display device with negative contrast, that is to say, light symbols on a dark background, the adhesive fixing points 9 are invisible, since the electrodes, which are configured, for example, as lines of print, are sufficiently far apart.

The invention is, of course, not restricted to display devices of the kind which have been described in the preceding text. It is also possible to manufacture, according to the invention, display devices which are operated in transmission, and/or in accordance with the guest/host effect. In such instances, the adhesive fixing points must be appropriately colored.

List of reference numbers

1 Polarizer
2 Front carrier plate
3 Front electrode
4 Liquid crystal
5 Reflector
6 Rear electrode
7 Rear carrier plate
8 Glass fiber
9 Adhesive fixing point
10 Border

Claims

1. A display device with liquid crystal, this device possessing two mutually parallel carrier plates (2, 7) which, with a border (10), which is made of fiber-type material and defines the clearance between the carrier plates (2, 7), form a cell, into which a liquid crystal layer (4) is introduced, possessing a front electrode (3) and a rear electrode (6), possessing additional fibers (8), as spacers, in the region of the liquid crystal layer, and with a cured adhesive, wherein the border (10) is composed of adhesive with a plurality of fibers, wherein the adhesive forms a regular grid, composed of adhesive fixing points (9), on the carrier plates (2, 7), wherein the fibers (8) have a diameter of 2 to 15 μm, and a maximum length of 200 μm, and wherein the fibers (8) are randomly distributed over one of the carrier plates.

2. The display device as claimed in claim 1, wherein the smallest unit defining the grid is

square or rectangular, and has a point-separation of 1 to 10 mm.

3. The display device as claimed in claim 2, wherein the fibers (8) are composed of glass or plastic, and have a diameter of 5 ± 0.2 μm and a length of approximately 50 μm.

4. The display device as claimed in claim 3, wherein the plastic fibers are composed of Kevlar.

5. The display device as claimed in claim 3, wherein a circular polarizer (1) is attached to the front carrier plate (2), and an internal reflector (5) is attached, via the rear electrode (6), and the liquid crystal layer is homeotropic in the field-free state.

6. The display device as claimed in claim 5, wherein the internal reflector (5) is composed of aluminum flakes, in a layer of CeO, MgO, SiO_2, TiO, TiO_2, ZrO_2, Al_2O_3, or Gd_2O_3.

7. The display device as claimed in claim 1, wherein the carrier plates (2, 7) are made of glass, and are no more than 3 mm thick.

8. The display device as claimed in claim 1, wherein the carrier plates (2, 7) are plastic sheets, with a maximum thickness of 1 mm.

9. A process for manufacturing a display device as claimed in claim 1, wherein the adhesive is printed on by screen-printing, wherein the fibers are uniformly distributed over the carrier plate, and wherein the adhesive cures under a contact pressure which is constant both with respect to time and over the surface area.

10. The process as claimed in claim 9, wherein the adhesive is composed of an epoxy resin-based hot-melt bonding agent.

11. The display device as claimed in claim 1, substantially as described with reference to the accompanying drawing.

12. A display device manufactured by a process as claimed in claim 9 or 10.

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